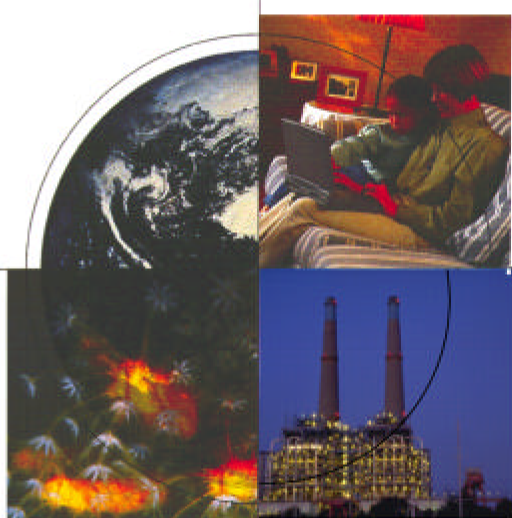
CARBON SEQUESTRATION TECHNOLOGY ROADMAPPING



Pathways to Sustainable Use of Fossil Energy

MAY 2001

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

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A MESSAGE TO OUR STAKEHOLDERS

Carbon sequestration has emerged as a third option for reducing greenhouse gas emissions. Joining improved energy efficiency and the use of low-carbon fuels, carbon sequestration will enable the removal and permanent storage of carbon dioxide (CO_2) from fossil-energy systems. Carbon sequestration holds great potential to reduce greenhouse gases at costs and impacts that are economically and environmentally acceptable.

The effort to develop carbon sequestration technology is international in scope, and involves extensive collaboration among government, industry, academia, non-government organizations, and the public-at-large. This technology roadmapping effort represents an on-going exchange of information among policy makers, technology developers, regulators, and the public. It is based on ideas, data, and perspectives developed by a broad range of stakeholders over the past several years.

As carbon sequestration is a new area of science and technology, the roadmap will evolve as more information becomes available from ongoing policy analysis and technology planning efforts. To date, an extraordinary amount of progress has already taken place.

The theme of the First National Conference on Carbon Sequestration, May 2001, is "Progress through Partnership." We invite you to join us in forging a path to future success in this critical area of science and technology.

Rita A. Bajura *Director, National Energy* *Technology Center*	*George Rudins* *Deputy Assistant Secretary* *for Coal and Power Systems*

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Carbon Sequestration Technology Roadmapping

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CARBON SEQUESTRATION TECHNOLOGY ROADMAPPING

I. Introduction

The carbon sequestration technology roadmapping activity represents a collaborative effort of the Department of Energy (DOE), industry, academia, and the public. Based on a pioneering effort of the DOE Office of Fossil Energy (FE) and DOE Office of Science, it has evolved to date based on two years of outreach with industry and other stakeholders.

The term “carbon sequestration” refers to the removal of carbon dioxide (CO_2) from man-made emissions or the atmosphere and the safe, essentially permanent storage as CO_2 or other carbon compounds, or the reuse of CO_2 through chemical or biological conversion to value-added products. Until the late 1990s, carbon sequestration was not yet in the scientific lexicon. It likely is less familiar to the public-at-large than the other two options for reducing greenhouse gases—improved efficiency and the use of low-carbon fuels.

A. Overview

The framework of the evolving carbon sequestration technology roadmap is shown in Figure 1. It defines the major drivers and challenges, R&D pathways, and desired outcomes that have been identified to date. This framework represents a general consensus to date on *what* major science and technology pathways have the potential for achieving the goals of carbon sequestration. The implementation of research and development for these pathways—*how* the work will be accomplished—will be carried out by various stakeholders.

The roadmap has five major pathways.

- Separation and Capture
- Ocean Sequestration
- Storage in Terrestrial Ecosystems
- CO_2 Storage in Geologic Formations
- Conversion and Utilization

The pathways encompass a broad set of opportunities. There are two main types of sequestration: *direct* sequestration, where CO_2 is removed from energy systems, and *indirect* sequestration, where CO_2 is removed from the ambient atmosphere by enhanced natural processes. The final storage form may be as CO_2 or in other carbon compounds.

There are several important issues that crosscut many of the pathways. For example, for direct sequestration processes, the transportation of CO_2 from source to receptor must be addressed. For indirect sequestration, the CO_2 flux—the amounts taken up and released—must be determined to measure the net amount of CO_2 sequestered. For all pathways, there must be an accepted system to measure and verify the amount of carbon sequestered. Finally, public acceptance of the pathways must be assured.

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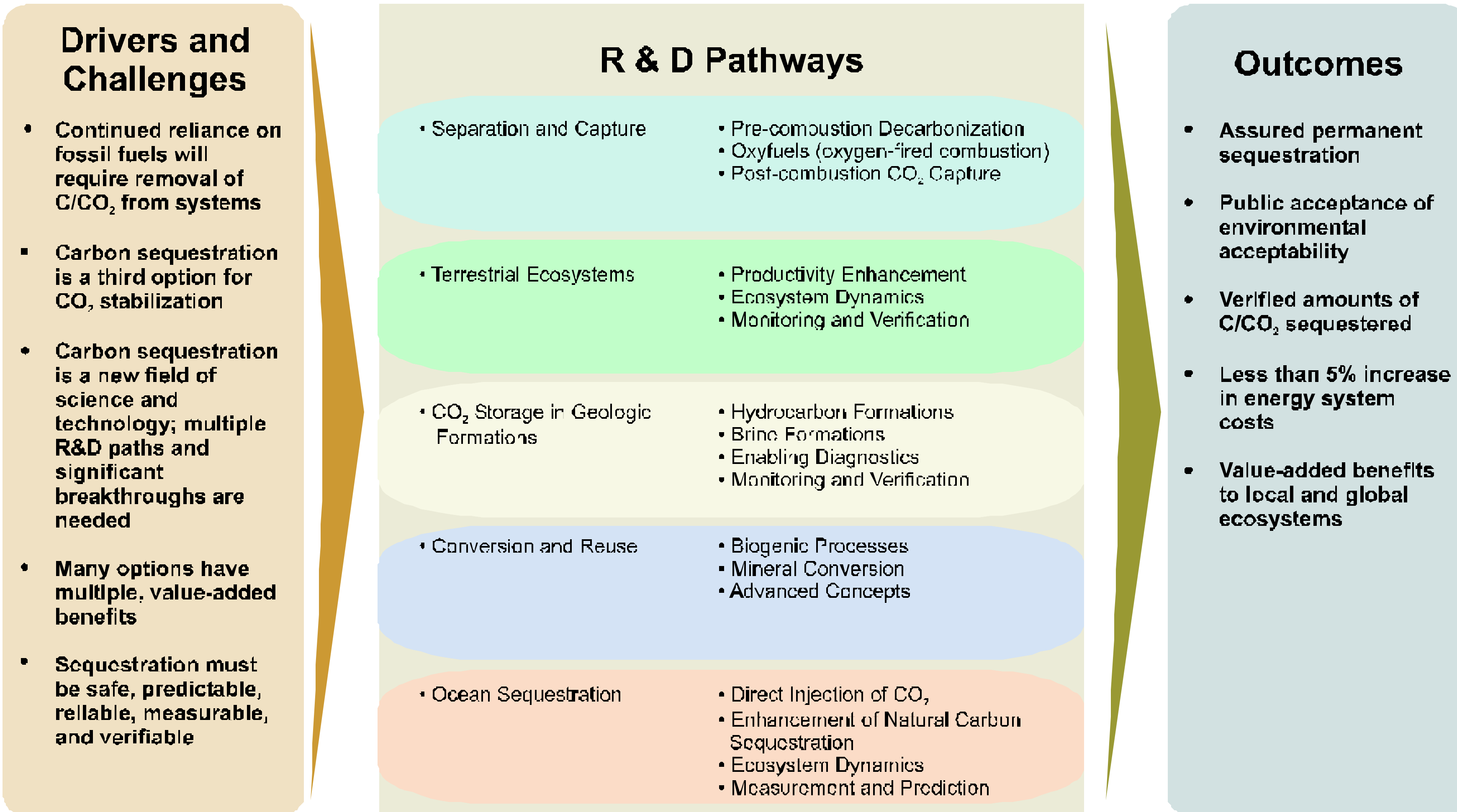
Figure 1. A Framework for Carbon Sequestration Technology Roadmapping



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B. Vision and Goals

The vision for carbon sequestration is to possess the scientific understanding of carbon sequestration and develop those technology options that ensure environmentally acceptable sequestration, thus reducing anthropogenic emissions and overall atmospheric concentrations.

There are five major goals that support this vision.

- Assure essentially permanent storage,
- Demonstrate environmental acceptability to the public,
- Verify the amount of carbon or CO_2 sequestered,
- Require less than a 5% increase in energy system costs, and
- Provide value-added benefits to local and global ecosystems.

C. The Collaboration that Brought Us Here

From the Department of Energy's perspective, 1999 represented the start of FE's formal carbon-sequestration efforts, with initial funding of the FE Carbon Sequestration Program. It was also the year the joint Office of Fossil Energy and Office of Science report *Carbon Sequestration: State of the Science* was released defining five major pathways for sequestration. Since then, FE has worked with international and domestic stakeholders in a series of collaborative efforts.

The goal of these efforts has been to develop a *consensus* view on the key science and technology needs and opportunities. As in any new area of science and technology, there is still significant uncertainty. There are also areas where there may be disagreement over what path to follow—and how to follow them. These differing opinions are part of the scientific process. As our knowledge base improves, some pathways will likely become more important and others less so.

The individual pathways may be pursued by different stakeholders. In addition to the FE Carbon Sequestration Program, other organizations, public and private, are currently or may in the future work on these and other, new pathways. There are many collaborative efforts to date that drive the roadmap evolution. They include:

- A workshop on geologic storage was jointly sponsored with BP and the IEA Greenhouse Gas R&D Programme in September 1999. This workshop, *CO_2 Capture and Geologic Sequestration: Progress through Partnership*, was successful in bringing together a diverse group of experts in CO_2 capture and geologic sequestration. Over 140 participants attended the workshop. Seventy-five percent of the participants were from industry, with 30% of the participants coming from outside the United States.

- In collaboration with the DOE Office of Science, a series of workshops with university and National Laboratory participants was held to identify possible science and technology pathways. The output of this effort is contained in the joint FE/OS report *Carbon Sequestration State of the Science*, April, 1999. In developing a carbon sequestration roadmap, this report concludes: "This report should be used as a framework in organizing a wider examination by diverse stakeholders of the science and technology required for carbon capture and sequestration."

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- CO_2NET, a European technology-networking program, is designed to facilitate cooperation in geological sequestration projects. Sponsored by the European Commission, CO_2NET partners include Technology Initiatives Ltd., the IEA Greenhouse Gas Programme, the Geological Survey of Denmark and Greenland, Statoil, BP, and the British Geological Survey. CO_2NET objectives are to enhance the performance and impact of associated projects and increase worldwide awareness of European objectives, activities, and results.

- The Office of Fossil Energy *Vision 21 Technology Roadmap*, April 2001, which is based on two industry workshops held in December 1998 and August 2000. The Environmental Control Technology area addresses the control of criteria pollutants and multi-media control that would intersect with CO_2 control in a "zero-emissions" Vision 21 plant.

- *CO_2 Geologic Storage Monitoring and Verification (SMV) Technology Development*, January 2001, a workshop sponsored by industry participants Chevron, BP, Norsk, Hydro, Statoil, Shell International, Shell Canada, Suncor, and Texaco. Objectives and discussions of the workshop focused on challenges of storage, monitoring, and verification of CP2 storage in geologic formations. Discussion of safety, friendly, and efficient storage of CO_2 to the public and environmental non-government groups was paramount in significance.

- The *Coal Utilization Research Council (CURC) Technology Roadmap*, (updated) January 2001 is the product of CURC membership "to guide the application of resources in the development of technologies intended to ensure the long-term utilization of coal." The roadmap addresses CO_2 capture and sequestration technology from the perspective of current knowledge gaps in the science and technology. The roadmap states: "As a result of these very large knowledge gaps, it is extremely important that significant R&D investments are made so the technology that is needed to cope with the CO_2 emission issue is available, if and when needed, and that the costs and environmental impacts of implementation are well understood."

Based on experiences to date there are many areas of agreement where collaborative R&D is being planned and performed today. This is consistent with the general consensus of the scientific community today—that there are near-term actions to be taken as we work to gain better understanding of the long-term opportunities for sequestration.

D. Next Steps

"Progress through Partnership," the theme of the First National Conference on Carbon Sequestration, May 2001, will guide the roadmap's evolution. Feedback from conference participants and others is encouraged. We recognize that there are differing political, regulatory and economic perspectives in the global climate change issue. None-the-less, the prevailing consensus as we move forward is that there are significant, positive actions to be taken in the near-term as longer-term pathways and solutions emerge.

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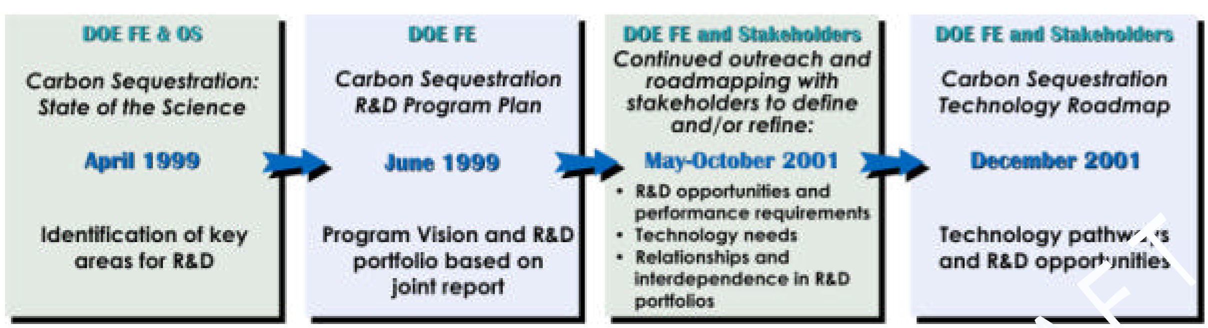
Over the next six months, FE will conduct a series of outreach and collaborative planning efforts.

- In August 2001, a detailed roadmap draft will be available from the Carbon Sequestration Program. The draft will reflect input from the above-noted efforts as well as from a number of recent or planned stakeholder workshops. These include:
  - American Society of Limnology and Oceanography (ASLO) *Ocean Fertilization Workshop*, April 23-25, 2001, Washington DC. This recent workshop sponsored by the National Science Foundation, the DOE Office of Science, and the National Oceanic and atmospheric Administration, considered scientific and policy uncertainties surrounding ocean fertilization to remove atmosphere CO_2.
  - CO_2NET's *CO2 Technology Scenarios Convention and Thematic Network Planning Meeting*, June 6-8, 2001, Copenhagen, Denmark. European and other projects in the field of CO_2 capture and sequestration into geological storage will be reviewed from an operational perspective. Through scenario building, technology gaps and areas for further research will be identified and developed.
  - The *First National Conference on Carbon Sequestration*, May 14-17, 2001, Washington, DC. Sponsored by the DOE's National Energy Technology Laboratory, the conference will provide a forum where scientists, engineers, and policy makers can present new information that addresses the full spectrum of issues surrounding carbon sequestration.

- In October 2001, the program will host a stakeholder's workshop to gather input on the latest science and technology developments and recommended changes to the draft roadmap.

- In December 2001, the program will publish the first detailed vision of the roadmap.

The roadmap will be a "living" document, with the framework and details evolving as new data, information, and opportunities are defined. As significant changes in our understanding of carbon sequestration emerge, the roadmap will be revised accordingly.



Roadmap Evolution

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II. Background: Global Climate Change and CO_2 Emissions

Predictions of global energy use in the next century suggest a continued increase in carbon emissions and rising concentrations of CO_2 in the atmosphere unless major changes are made in the way we produce and use energy—in particular, how we manage carbon. About 75% of the world's commercial energy comes from fossil fuels, and about 84% of the energy used in the United States is derived from fossil fuels (EIA 1998a; PCAST 1997). Given the advantages inherent in fossil fuels, such as their cost-competitiveness, their availability, their ease of transport and storage, and the large fossil resources, fossil fuels are likely to remain a primary source of global energy supply for at least the next century.

The Intergovernmental Panel on Climate Change (IPCC) predicts in its 1995 "business as usual" energy scenario that future global emissions of CO_2 to the atmosphere will increase from 7.4 billion metric tonnes of carbon (GtC) per year in 1996 to approximately 26 GtC/year by 2100. IPCC also projects a doubling of atmospheric CO_2 concentration by the middle of next century and growing rates of increase beyond. Although the effects of increased CO_2 levels on global climate are uncertain, many scientists agree that a doubling of atmospheric CO_2 concentrations could have a variety of serious environmental consequences.

A. The Three Options

One way to manage carbon is to use energy more efficiently to reduce our need for a major energy and carbon source—fossil fuel combustion. Another way is to increase our use of low-carbon and carbon-free fuels and technologies (nuclear power and renewable sources such as solar energy, wind power, and biomass fuels). Both options are supported by the U.S. Department of Energy.

The third option to manage carbon, carbon sequestration, is truly radical in a technology context. For over 200 years, the development of energy technology has been focused on lowering costs through increased efficiency to support economic growth. Because of their abundance, availability, and high energy content, coal, oil, and natural gas have proved to be attractive energy sources to produce electricity, run industrial processes, propel transportation vehicles, and provide energy for residential and commercial applications. As fossil energy use increased and adverse environmental effects became apparent, energy technology evolved to minimize them.

However, all of this enormous technology development has assumed that the free venting of CO_2 to the atmosphere was environmentally harmless. Only recently has the increasing concentration of CO_2 in the atmosphere been considered a serious environmental problem. As a consequence we have developed an intricate, tightly coupled energy system that has been optimized for economy, efficiency, and environmental performance, but not for the capture and sequestration of its largest material effluent, CO_2.

B. The Global Carbon Cycle

Our understanding of the global carbon cycle, its fluxes, and its reservoirs, is intimately tied to successful implementation of carbon sequestration technologies. Decreasing atmospheric CO_2 concentrations by reducing CO_2 emissions or by changing the magnitude of the fluxes between reservoirs is controlled by the carbon budget of a reservoir. From a carbon sequestration

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perspective, understanding the potential to alter carbon budgets through the intervention of carbon sequestration technologies to reduce future atmospheric CO_2 concentrations is a crosscutting challenge for all pathways.

Carbon exchanges between reservoirs are quite large (100s of GtC per year), while net carbon exchanges are several orders of magnitude smaller. For example, carbon exchange between the atmosphere and terrestrial biosphere averages about 120 GtC per year, more than 2 orders of magnitude higher than net terrestrial uptake. Similarly, ocean exchanges are approximately 182 GtC per year, while net ocean uptake is approximately 2 GtC. Developing the ability to alter the gross annual carbon exchanges of the global carbon cycle by a small percentage through carbon sequestration technologies would increase net storage of carbon in the major reservoirs and reduce atmospheric carbon emissions.

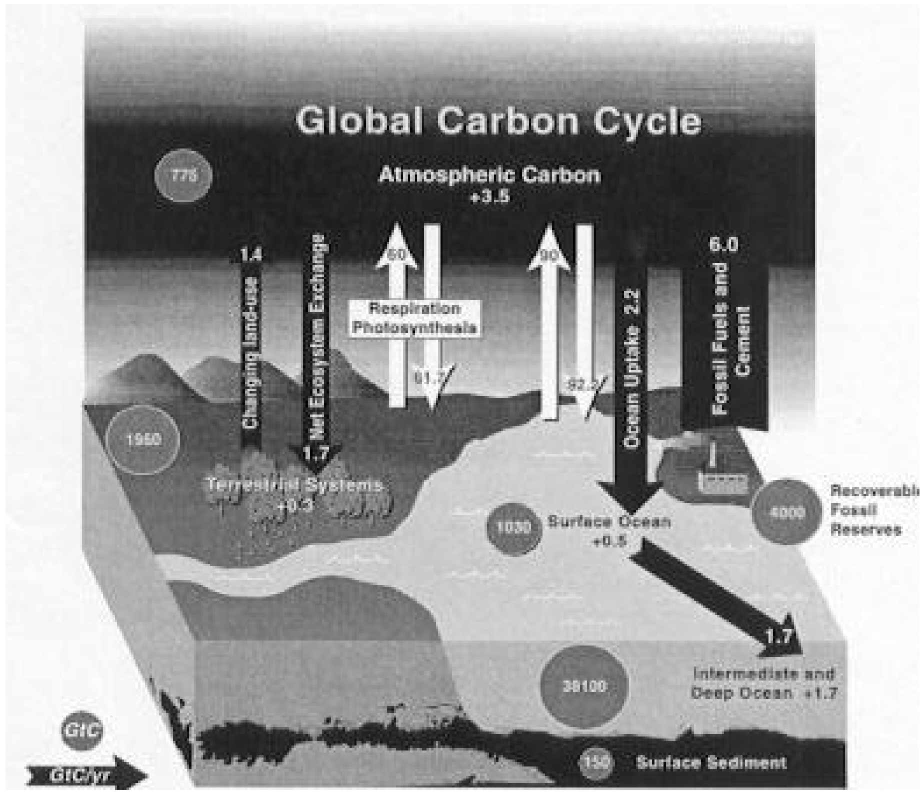

Figure 2. The Global Carbon Cycle

C. Other Greenhouse Gases

Carbon dioxide is one of many gases that contribute to the greenhouse effect. Indeed, water molecules (H_2O) are the primary determinant of the phenomenon. Water content in the atmosphere, however, is not changed significantly by the activities of man. In addition to CO_2, methane (CH_4) and nitrous oxide (N_2O) are the other anthropogenic emissions that contribute to global climate change. On a molecular basis, both CH_4 and N_2O are more potent greenhouse gases than CO_2. However, in terms of emissions, CO_2 far outstrips the others and is thus the primary focus of mitigation efforts. Control of CH_4 and N_2O is considered however, in the analysis of "multi-gas" impacts and mitigation potential.

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III. Major Pathways

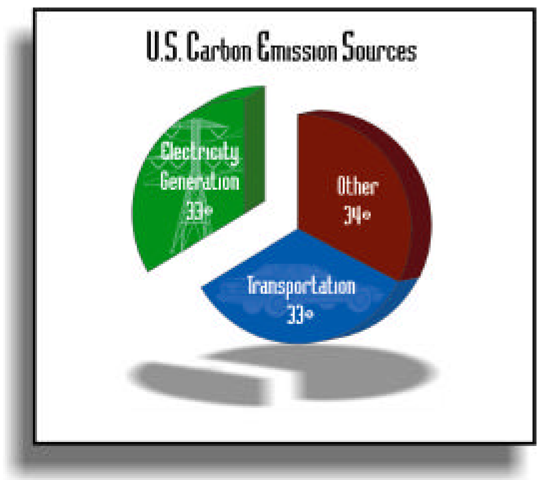
The report *Carbon Sequestration State of the Science* identified five major pathways to carbon sequestration:

- Separation and capture,
- Ocean sequestration,
- Terrestrial Ecosystems,
- Sequestration of CO_2 in geologic formations, and
- Conversion and utilization.

These five pathways form the high-level framework for the roadmap.

A. Separation and Capture

CO_2 separation and capture is a means of direct sequestration, and entails capturing CO_2 from power plants, industrial processes, fuels manufacturing, and other energy systems before it is emitted to the atmosphere. While the technology exists to perform this today, the key barrier is cost. Using currently available technology, separation and capture would increase energy costs by 50% or more. Research and development is aimed at developing capture systems with the following characteristics:



- Low capital cost
- Low parasitic load
- High percent reduction in emissions
- Integrated with criteria pollutant control

Because of the enormous amount of existing fossil conversion systems, much of the R&D is aimed at CO_2 capture systems that are amenable to current air combustion boiler technology. There are also R&D efforts aimed at producing fundamentally new energy conversion systems that produce pure, high-pressure CO_2 as a natural consequence.

R&D pathways associated with CO_2 capture were identified in an industry-led workshop co-funded by BP Amoco, IEA Greenhouse Gas R&D Programme and the U.S. Department of Energy held in September 1999. This workshop consisted of:

- International, national, and industry perspectives
- Panel discussions on CO_2 capture and geologic sequestration technologies
- Status reports from ongoing CO_2 sequestration projects
- Working sessions to develop an industry work program leading to breakthroughs in costs and performance

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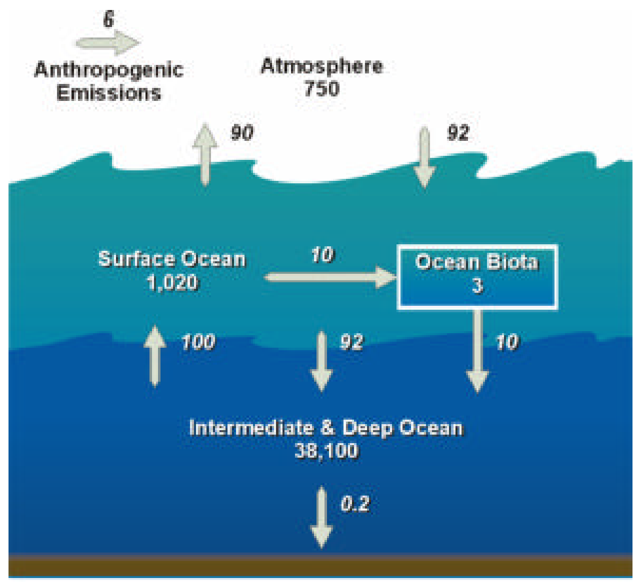
For separation and capture, the workshop defined and examined three pathways: pre-combustion decarbonization, oxyfuels (oxygen-fired combustion), and post-combustion decarboniszation. Currently, efforts are continued within FE and in collaboration with others to further define the separation and capture pathway.

B. Ocean Sequestration

The oceans contain carbon in the form of dissolved CO_2, plant and animal matter, and mineral carbonates (shells). The amount of carbon stored in the oceans is enormous; 39,000 billion metric tons compared to 2,000 billion tons in terrestrial ecosystems. However, little is understood about the deep ocean ecosystem and R&D efforts in the area of ocean sequestration are being pursued with caution. Because of their enormous size the oceans remain an important long-term carbon sequestration option. Pathways for ocean sequestration include direct sequestration, in the form of CO_2 injection into the oceans, and indirect sequestration through the enhancement of the ocean's CO_2 uptake from the atmosphere.



Reservoirs - billions of tonnes of carbon

Fluxes - bilions of tonnes of carbon per year

Source: "Atmospheric Carbon Dioxide and the Ocean," Siegenthaler and Sarmiento, *Nature* volume 365, pp 119-125.

Goals of R&D in the area of ocean sequestration are to:

- Gain an understanding of the ocean carbon cycle and deep ocean ecosystems, and
- Learn more about the environmental effects of actions aimed at increasing the amount of CO_2 stored in the ocean.

Development of the ocean sequestration pathway will be a collaborative effort involving oceanic experts. In particular, results of recent workshops hosted by the American Society of Limnology and Oceanography (ASLO) and the Monterey Bay Aquarium Research Institute (MBARI) will help guide the roadmap's development.

C. Terrestrial Ecosystems

In the process of photosynthesis, plants absorb CO_2 and release oxygen. The carbon from the CO_2 is biochemically transformed into sugar compounds necessary for plant growth and structure. Most of the carbon eventually cycles back to the atmosphere but a fraction is deposited in wetland sediments. Through indirect sequestration, anthropogenic carbon emissions can be partially offset by increasing the amount of carbon stored in the terrestrial ecosystem.

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Increasing carbon storage in terrestrial ecosystems can provide significant collateral benefits, including improved soil quality, increased wildlife habitat, reduced runoff, and increased production of agricultural and forest products.

R&D in the area of terrestrial sequestration is focused on:

- ♦ Increasing CO_2 uptake and storage to both plant matter and soils, and
- ♦ Developing technology to definitively measure the amount of carbon stored in a terrestrial ecosystem and to verify that efforts have resulted in increased carbon storage.

The roadmapping effort will be coordinated with a range of stakeholders. These include, for example, the U.S. Forest Service of the Department of Agriculture, environmental non-governmental organizations, state and local organizations, the Office of Surface Mining of the Department of Interior and the DOE Office of Science.

D. Sequestration of CO_2 in Geologic Formations

Geological sequestration is a form of direct sequestration, with CO_2 being stored in geologic formations. Geologic formations are likely to be the first large-scale options for CO_2 storage, as developers of geologic sequestration technologies can draw from experience gained from oil, gas, coal and water-resource management.

There are three major types of geologic formations that are amenable to long-term CO_2 storage: active and depleted oil and gas reservoirs, deep coal seams and coal-bed methane formations, and saline formations.

Benefits of geologic sequestration include their close proximity to many large-point CO_2 sources. Also, geologic sequestration in active and depleted oil and gas reservoirs and unmineable coal seams can enhance recovery of fossil resources. Three primary goals of research in this area are to

- ♦ Develop field practices that lower the cost of storage and ensure formation integrity,
- ♦ Quantify the cost of storage and relative value of by-products, and
- ♦ Demonstrate the environmental acceptability of underground storage in a wide range of geologic formations.

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The roadmapping effort will build on input obtained from several sources. These include a workshop co-funded by BP, the IEA Greenhouse Gas R&D Programme (GHG) and the Department of Energy in September 1999 and CO_2NET, a technology networking program sponsored by the European Commission.

E. Conversion and Utilization

An alternative to storing CO_2 is to convert it into fuels, useful products, or benign solids. Numerous CO_2 conversion phenomena are found in nature, but the processes are slow as CO_2 is an extremely stable compound.

Although the technology barriers in the area of CO_2 conversion and reuse are high, the potential payoff is large. Technology breakthroughs could lead to regenerable carbon-based energy systems or permanent, benign carbon storage.

Goals of the R&D in this area are to:

- ♦ Improve the speed and energy efficiency of CO_2 conversion processes,
- ♦ Identify conversion processes that produce high-value by-products to improve process economics, and
- ♦ Explore novel ideas.

Roadmapping efforts are being coordinated with the DOE Office of Science and other basic research organizations. Efforts will focus on identifying paths of potential high payoff in the long term, and engaging a diverse net of researchers to identify new research ideas and multi-disciplinary approaches.

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VIII. The Path Forward for the Carbon Sequestration Program

The roadmapping activity is an iterative process. At a given point in time, the roadmap will provide a snapshot of our current knowledge and understanding. Based on the emerging technology roadmap, the Carbon Sequestration Program is implementing a program for selected pathways. Figure 2 provides an overview of program implementation. As with the roadmap, program implementation will naturally evolve over time as new information and R&D results become available. To facilitate this process, the Carbon Sequestration Program will focus on a series of outreach efforts:

- Continued development and refinement of currently-identified pathways, with a detailed roadmap draft in August 2001 and a stakeholder workshop in October 2001,
- Working with environmental non-governmental organizations to further define efforts required to assure environmental acceptability,
- Assessing critical crosscutting issues such as measurement and verification of the amounts of carbon sequestered,
- Exploring novel concepts that may lead to entirely new pathways, particularly in the area of conversion and reuse, and
- Public outreach activity to provide information and educational materials about carbon sequestration as a third option.

These efforts will serve two purposes.

- Further defining the technology roadmap on *what* technology pathways should be explored and
- Supporting the ongoing, iterative process of program planning and analysis on *how* the Carbon Sequestration Program and other implementing organizations (e.g., industry, IEA, the DOE Office of Science) are pursuing various pathways.

As we move forward, we may find some pathways may not be viable due to environmental economic, technical, or other reasons. Given that the carbon sequestration is basically in its infancy in terms of science and technology, we may expect discoveries that will open new pathways. Through the process of roadmap development, the R&D opportunities that can turn possibilities into realities will be identified.

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Figure 2. Carbon Sequestration Program Implementation Overview

Area	Key Issues	Status	Approach	Program Synergies
Capture	• High capital and operating cost. • Reduced efficiencies	• Current cost at 30-50 $/ton CO_2, from an existing coal-fired power plant • Up to 35% reduction in net power production due to efficiency losses.	• Develop: – Improved conventional technology – Advanced capture technology – Processes that concentrate CO2 during fuel conversion	• V21 • Innovations for Existing Plants
Geologic	• Public awareness and recognition of the value of large-scale storage of CO_2 • Environmental acceptability and storage verification & monitoring	• Significant number of natural CO_2 storage analogs exist • Experience with large scale injection of CO_2 into underground formations: – Significant with oil reservoirs – Much less with gas reservoirs and coal seams – Limited with saline formations, (Statoil has been injecting 1 mm tons of CO_2 per year into the Sleipner saline formation since 1996)	• Address public concerns by obtaining field experience with CO2 storage – Develop increased understanding of Natural Analogs – Develop methods and technologies for tracking CO_2 migration underground and verifying storage integrity – Develop best practices for CO_2 injection that lead to stable storage	• EOR, EGR, ECBM • DOE/OS • USGS
Terrestrial	• Idealogical resistance to terrestrial sequestration to offset emissions versus emissions reduction • Cost-effective methods for monitoring & verifying (M&V) carbon in terrestrial ecosystems	• Utilities and other entities engaged in numerous forestation and reforestation/enhancement activities in anticipation of tradeable credits. • Promising M&V technologies exist, but are not adequately proven for acceptability and scalability (esp. soil carbon)	• Demonstrate the multiple benefits associated with terrestrial sequestration, particularly on disturbed lands. • Verify new technology for monitoring and verification of carbon in terrestrial ecosystems.	• Innovation for Existing Plants • DOE-OS • USDA/USFS • OSM
Ocean	• Environmental aspects of increased carbon storage in the ocean unknown • Deep public concerns over future health of oceans	• Inadequate scientific understanding of the ocean carbon cycle. • Data to determine ecological and environmental parameters not available	• Collaborate with DOE-OS, NSF and international entities to conduct exploratory scientific experiments • Investigate CO_2 hydrates formation and stability related to CO_2 storage.	• EGR (Hydrates) • DOE-OS • NSF
Conversion and Utilization	• Limited markets for CO_2 • CO_2 conversion not economic: – slow reactions – large energy requirements	• 30MM tons per year CO_2 used in the U.S. for EOR, 7MM from man-made point sources • No economical applications of CO_2 conversion identified to date; concepts are at the exploratory research stage.	• Expand technology base for value-added applications for CO_2: EOR, EGR, ECBM, etc. • Conduct exploratory research to discover new biological and chemical CO_2 conversion processes	• Advanced Research • DOE-OS

Acronym Key: ECBM (Enhanced Coal Bed Methane), CCB (Coal Combustion Byproduct), DOE-OS (Department of Energy - Office of Science), EGR (Enhanced Gas Recovery), EOR (Enhanced Oil Recovery), NETL (National Energy Technology Laboratory), NSF (National Science Foundation), OSM (Office of Surface Mining), USDA (United States Department of Agriculture), USFS (US Forest Service), USGS (US Geologic Survey), V21 (Vision 21)

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For more information on the Carbon Sequestration Program please visit our web sites:

- **$** DOE Carbon Sequestration Page @ http://www.fe.doe.gov/coal_power/sequestration/index.html
- **$** NETL Carbon Sequestration Page @ http://www.netl.doe.gov/products/sequestration

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